

CLAIMS

The invention claimed is:

1. An atomic layer deposition method of forming a conductive metal nitride comprising layer, comprising:

positioning a substrate within a deposition chamber;

chemisorbing a first species to form a first species monolayer onto the substrate from a gaseous first precursor comprising at least one of an amido metal organic compound or an imido metal organic compound, the first species monolayer comprising organic groups;

contacting the chemisorbed first species with a second precursor plasma effective to react with the first species monolayer to remove organic groups from the first species monolayer; and

successively repeating said chemisorbing and contacting under conditions effective to form a layer of material on the substrate comprising a conductive metal nitride.

2. The method of claim 1 wherein the gaseous first precursor comprises an amido metal organic.

3. The method of claim 2 wherein the amido metal organic is a tetrakis amido metal compound.

4. The method of claim 1 wherein the gaseous first precursor comprises an imido metal organic.

5. The method of claim 1 wherein the second precursor plasma comprises hydrogen.

6. The method of claim 5 wherein the second precursor plasma comprises at least one of SiH_4 , Si_2H_6 , BH_3 , and B_2H_6 .

7. The method of claim 5 wherein the second precursor plasma comprises H_2 .

8. The method of claim 5 wherein the second precursor plasma consists essentially of H_2 .

9. The method of claim 1 wherein the second precursor plasma is void of hydrogen.

10. The method of claim 1 wherein the second precursor plasma is void of nitrogen.

11. The method of claim 1 wherein the second precursor plasma comprises NH_3 .

12. The method of claim 1 wherein the second precursor plasma consists essentially of NH_3 .

13. The method of claim 1 wherein the second precursor plasma comprises CO.

14. The method of claim 1 wherein the first precursor consists essentially of tetrakisdimethylamido hafnium, the second precursor plasma consists essentially of H_2 , and the conductive metal nitride comprises hafnium nitride.

15. The method of claim 1 wherein the first precursor consists essentially of tetrakisdimethylamido titanium, the second precursor plasma consists essentially of NH_3 , and the conductive metal nitride comprises TiN.

16. The method of claim 1 wherein the chemisorbing with the first species is void of plasma.

17. The method of claim 1 wherein the chemisorbing with the first species is void of plasma, and further comprising feeding the second precursor to the chamber in the absence of plasma during the chemisorbing.

18. The method of claim 1 wherein the second precursor plasma is generated from feeding the second precursor to the deposition chamber with plasma power being applied to the second precursor within the deposition chamber.

19. The method of claim 18 wherein said plasma power is started prior to feeding the second precursor to the deposition chamber and continued while feeding the second precursor to the deposition chamber.

20. The method of claim 18 wherein said plasma power is continued after stopping feeding of the second precursor to the deposition chamber.

21. The method of claim 18 wherein said plasma power is started prior to feeding the second precursor to the deposition chamber, continued while feeding the second precursor to the deposition chamber, and continued after stopping feeding of the second precursor to the deposition chamber.

22. The method of claim 1 wherein the second precursor plasma is generated from applying plasma power to a flowing second precursor externally of the deposition chamber.

23. The method of claim 1 wherein the metal of the metal nitride is selected from the group consisting of any of metal groups 3, 4, 5, 6, 7, the lanthanide series and the actinide series of the periodic table, and mixtures thereof.

24. The method of claim 1 comprising a period of time intermediate said chemisorbing and contacting wherein no gas is flowed to the deposition chamber.

25. The method of claim 24 wherein the second precursor plasma is generated from feeding the second precursor to the deposition chamber with plasma power being applied thereto within the deposition chamber, said plasma power being started prior to feeding the second precursor to the deposition chamber during said period of time and continued while feeding the second precursor to the deposition chamber.

26. The method of claim 1 wherein pressure within the chamber during the chemisorbing is lower than during the contacting.

27. The method of claim 1 wherein pressure within the chamber during the chemisorbing is at least five times lower than during the contacting.

28. The method of claim 1 wherein pressure within the chamber during the chemisorbing is at least ten times lower than during the contacting.

29. The method of claim 1 wherein metal atoms are present in the conductive metal nitride at an atomic ratio of metal atoms to nitrogen atoms at greater than 1:1.

30. The method of claim 1 wherein the conductive metal nitride comprises carbon.

31. The method of claim 30 wherein carbon is present in the conductive metal nitride at an atomic ratio of carbon atoms to metal atoms of no greater than 1:3.

32. The method of claim 31 wherein metal atoms are present in the conductive metal nitride at an atomic ratio of metal atoms to nitrogen atoms at greater than 1:1.

33. The method of claim 1 wherein the layer of material has a resistivity of no greater than 5×10^3 microhm·cm.

34. The method of claim 1 wherein the layer of material has a resistivity of no greater than 2×10^3 microhm·cm.

35. The method of claim 1 wherein the layer of material has a resistivity of less than 1×10^3 microohm·cm.

36. An atomic layer deposition method of forming a conductive metal nitride comprising layer, comprising:

positioning a substrate within a deposition chamber;

in the absence of plasma, chemisorbing a first species to form a first species monolayer onto the substrate from a gaseous first precursor comprising at least one of an amido metal organic compound or an imido metal organic compound, the first species monolayer comprising organic groups;

contacting the chemisorbed first species with a second precursor plasma effective to react with the first species monolayer to remove organic groups from the first species monolayer; the second precursor plasma being generated from feeding the second precursor to the deposition chamber with plasma power being applied to the second precursor within the deposition chamber; said plasma power being started prior to feeding the second precursor to the deposition chamber, continued while feeding the second precursor to the deposition chamber, and continued after stopping feeding of the second precursor to the deposition chamber; and

ceasing said plasma power at some point after stopping feeding of the second precursor, and then successively repeating said chemisorbing, contacting and ceasing under conditions effective to form a layer of material on the substrate comprising a conductive metal nitride.

37. The method of claim 36 wherein the gaseous first precursor comprises an amido metal organic.

38. The method of claim 37 wherein the amido metal organic is a tetrakis amido metal compound.

39. The method of claim 36 wherein the gaseous first precursor comprises an imido metal organic.

40. The method of claim 36 wherein the second precursor plasma comprises hydrogen.

41. The method of claim 40 wherein the second precursor plasma comprises at least one of SiH_4 , Si_2H_6 , BH_3 , and B_2H_6 .

42. The method of claim 40 wherein the second precursor plasma comprises H_2 .

43. The method of claim 40 wherein the second precursor plasma consists essentially of H_2 .

44. The method of claim 36 wherein the second precursor plasma is void of hydrogen.

45. The method of claim 36 wherein the second precursor plasma is void of nitrogen.

46. The method of claim 36 wherein the second precursor plasma comprises NH_3 .

47. The method of claim 36 wherein the second precursor plasma consists essentially of NH_3 .

48. The method of claim 36 wherein the second precursor plasma comprises CO.

49. The method of claim 36 wherein the first precursor consists essentially of tetrakisdimethylamido hafnium, the second precursor plasma consists essentially of H_2 , and the conductive metal nitride comprises hafnium nitride.

50. The method of claim 36 wherein the first precursor consists essentially of tetrakisdimethylamido titanium, the second precursor plasma consists essentially of NH_3 , and the conductive metal nitride comprises TiN.

51. The method of claim 36 further comprising feeding the second precursor to the chamber in the absence of plasma during the chemisorbing.

52. The method of claim 36 wherein the metal of the metal nitride is selected from the group consisting of any of metal groups 3, 4, 5, 6, 7, the lanthanide series and the actinide series of the periodic table, and mixtures thereof.

53. The method of claim 36 comprising a period of time intermediate said chemisorbing and contacting wherein no gas is flowed to the deposition chamber.

54. The method of claim 53 wherein said plasma power is started during said period of time.

55. The method of claim 36 wherein pressure within the chamber during the chemisorbing is lower than during the contacting.

56. The method of claim 36 wherein pressure within the chamber during the chemisorbing is at least five times lower than during the contacting.

57. The method of claim 36 wherein pressure within the chamber during the chemisorbing is at least ten times lower than during the contacting.

58. The method of claim 36 wherein metal atoms are present in the conductive metal nitride at an atomic ratio of metal atoms to nitrogen atoms at greater than 1:1.

59. The method of claim 36 wherein the conductive metal nitride comprises carbon.

60. The method of claim 59 wherein carbon is present in the conductive metal nitride at an atomic ratio of carbon atoms to metal atoms of no greater than 1:3.

61. The method of claim 60 wherein metal atoms are present in the conductive metal nitride at an atomic ratio of metal atoms to nitrogen atoms at greater than 1:1.

62. The method of claim 36 wherein the layer of material has a resistivity of no greater than 5×10^3 microhm·cm.

63. The method of claim 36 wherein the layer of material has a resistivity of no greater than 2×10^3 microhm·cm.

64. The method of claim 36 wherein the layer of material has a resistivity of less than 1×10^3 microhm·cm.